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**Examination Details & Draft Blueprint for**
Open Networking Foundation Certified SDN Professional Program

**ONF-Certified SDN Engineer Exam (CSDNE-111**)

**Exam Title:** ONF-Certified SDN Engineer (CSDNE-111)

**Exam Details:** 70 questions in 90 minutes and a pass score of 70%

**Exam Delivery:** Delivered electronically via secure login, with attestation and affirmation of academic integrity by the candidate. Exam to be available in English and Simplified Chinese by Q4 2015.

**Credential Awarded:** ONF Certified SDN Engineer (CSDNE) upon successful completion of the exam.

**Exam Purpose:** This certification exam attests and formally certifies that the successful candidate has vendor-neutral technical knowledge, skills, and abilities of the major domains of networking practices that support the theory and practice of Software Defined Networking (SDN). It presupposes deeper technical knowledge, skills, and abilities in computer networking practices, and will validate all the major aspects and domains of knowledge and practice in SDN networking environments. The certification will be considered mastery-level validation and certification examination for technical professionals in the domain of SDN networking.

**Intended Exam Audience**

| Job Position | Primary Job Responsibilities |
| --- | --- |
| SDN Sales Engineer | Create BOM’sHigh Level Architecture and DesignProduct Comparisons/CapabilitiesRFP’s/RFI’sProduct Line Updates |
| DevOps Engineer | Script & Automation IT Describe/Define IT AutomationProcess Re-engineering |
| Technical Marketing Engineer | Product Positioning and DifferentiationCompare/Contrast Products (Both Internal and External Products)Sales EnablementTechnical Documentation/White Papers/Collateral |
| Network Technician | Troubleshooting/Problem IsolationInstallation/MigrationMonitoringTrouble tickets and documenting/communicating issues via wiki etc.  |
| IT Analyst | Recommend IT Architectures/Products/SystemsTest Plans (product certifications for ONF)Performance & Monitoring (see above in Network Technician)Business ROI Comparisons  |
| Network Technician (Mid-grade Level) | Troubleshooting/Problem IsolationInstallation/MigrationMonitoringTrouble tickets and documenting/communicating issues via wiki etc. |
| IT Analyst (Mid-Grade Level) | Recommend IT Architectures/Products/SystemsTest Plans (product certifications for ONF)Performance & Monitoring (see above in Network Technician)Business ROI Comparisons Education (if there is public material or could use high level examples of ROI savings) |
| System Administrator (Mid-Grade Level) | Manage IT SystemsOperations ProcessDeploy Server/Storage Infrastructure (non-network)Hypervisors/Overlays/Virtual Switches |
| Consultant/Professional Services Engineer | Design/Implement Network ServicesROI/Capex/OpEx analysisBusiness Proposals authorship, managementRecommendations for Network Architecture/Integration |
| Student/EDU | Validate course level knowledge for online course in SDN engineering expertise foundations at a practitioner levelPracticing more advanced networking technologiesTech Evangelizing/White Papers/SpeakingUnderstanding from Academic/Theory and Practitioner Perspective |
| Network Engineer/Architect | Implementation/MigrationDesign/ArchitectureTroubleshooting/Operations |
| Network Security Engineer | Implementation/MigrationSecurity Assessments for Network InfrastructureCompliance Reviews (TBD) |
| Information Security/Assurance Engineer | Risk AssessmentCompliance Reviews (TBD)GovernanceApplication/Physical Security AnalysisMalwareIncident Response (TBD) |
| Hardware Engineer | Chip Design Platform Design/Implementation |
| Solution Architect | High Level DesignBusiness Requirements Analysis and TranslationTechnology EvangelismTraining and Mentoring |
| Technical Trainer | Course DevelopmentCourse DeliveryTechnology Evangelism |

**Prerequisite Knowledge and Recommended Training Materials**

In order to pass the ONF CSDNE Exam, a deep technical knowledge from a practitioner standpoint of computer networking is assumed, with specific experience with SDN networking also required. Resources that would be helpful include publications on networking, the ONF Certified SDN Associate™ certification, the CompTIA Network+™ professional certification, and materials freely available from Open Networking Foundation. Other materials may be referenced on <https://www.opennetworking.org/sdn-learning-resources>

**ONF Certified SDN Engineer Examination Blueprint (Draft)**

|  |  |
| --- | --- |
| Domain | % of Exam |
| 1. SDN Concepts | 10% |
| 2. OpenFlow | 25% |
| 3. SDN Architecture and Ecosystem | 15% |
| 4. SDN Implementations and Migrations | 25% |
| 5. Troubleshooting and Testing | 10% |
| 6. SDN Security | 10% |
| 7. SDN Futures | 5% |

**Domain 1. SDN Concepts**

Describe how SDN solves network issues and implements use cases

* SDN Value Proposition
* Implementing the SDN Forwarding Plane
* Implementing the SDN Control Plane
* Evolution of Switches and Control Plane
* Protocol Limitations that SDN solves
* Inadequacies in Networks today
* SDN Device Functions
* Application workflow
* Programmability (Netconf, Yang, REST)
* NFV and SDN Use Cases

**Domain 2. OpenFlow™**

Describe the OpenFlow Protocol message structures, features and headers

* Message Types and Headers
* Basic Operation/Packet Matching
* Creating Proactive vs Reactive Flows
* List Statistics/Counters
* Flow Timers
* Group Tables
* IPv6
* Optical Port Properties
* Port groups and Mapping
* Message Structures
* Instructions and actions
* Action Lists, Sets and Buckets
* Detailed Packet Matching/TLV’s
* Sub-Actions
* Metering

**Domain 3. SDN Architecture and Ecosystem**

Identify SDN architectural component design, API principals and SDN network design.

* Hybrid switch modes
* Reactive versus Proactive Applications
* Common API Primitives
* API Communication Protocols (REST, RESTCONF, JAVA)
* Controllers
	+ Open Source versus Vendor Specific
	+ Anatomy of a Controller
	+ Controller Redundancy
	+ Imperative/Declarative Paradigms
	+ Topology Discovery
	+ NBI Models/Implementations
* Software vs Hardware switches
* Managing Scalability

**Domain 4. SDN Implementations and Migrations**

List various SDN migration strategies and deployment options and considerations

* Controller Placement Design and Considerations/Implementations
* Application Considerations
* Scalability Considerations
* TCAM Limitations
* Simplifying OpenFlow with Table Type Patterns (TTP’s)
* Controller Federations
* Hierarchical Controllers
* Migration Strategies Greenfield/Hybrid/Mixed
* Migration Approaches
	+ Direct
	+ Phased
* Migration Planning
* Migration Best Practices
* Implications of a mixed network
* Carrier Ethernet Network Virtualization
* Packet-Optical Integration
* Optical Network Service Provider Data Center Interconnection (DCI)
* OpenStack and SDN Controller interaction

**Domain 5. Troubleshooting and Testing**

Given a scenario, demonstrate knowledge of how to configure and monitor and test an SDN Network.

* Troubleshooting Flow Table Scenarios
* Reading Flow Table Entries
* Packet/Wireshark Decoding/Debugging
* REST Messaging Types/Wireshark
* Curl debugging
* Mininet set-up
	+ ovs-ofctl
	+ mn sudo
	+ curl
* Description of the test program
	+ Test Profiles
	+ Standards
	+ Specifications
* Performance Benchmarking
* Tool Sets
	+ of-test
	+ wireshark dissector
	+ loxi
	+ flowsim
	+ flowvisor

**Domain 6. SDN Security**

Identify ways to secure SDN controllers and switches

* TCP level secure channel/communication/session establishment between controller/switch
* Controller HA
* The Implications of SDN on Network Security
* Securing the OF Protocol
* Securing the OF the data plane
* Software Development Lifecycle
* Controller/Element Hardening
* Securing users in a Wi-Fi environment

**Domain 7. SDN Futures**

List and describe SDN future projects and developments.

* Describe the purpose of Protocol Independent Forwarding (PIF) and Protocol Oblivious Forwarding (POF)
* Segment Routing
* TTP Use Cases
* Mobile traffic offload
* Pipeline Compiling
* Optical Extensions
* Security Extensions
* Wireless/Mobility Extensions

**List of Abbreviations, Terms, & Acronyms***note: terms and basic definitions referenced to Wikipedia and TechTerms.com, reference texts, as well as other non-proprietary sources, including ONF publications posted at* [*http://wwwopennetworking.org*](http://wwwopennetworking.org) *.*

|  |  |
| --- | --- |
| **Term, Abbreviation or Acronym** | **Full Text Name** |
| **3GPP** | third generation partnership project |
| **Abstraction** | a representation of an entity in terms of selected characteristics, while hiding or summarizing characteristics irrelevant to the selection criteria. |
| **ACL** | access control list |
| **A-CPI** | Application-controller plane interface |
| **AES** | advanced encryption standard |
| **API** | application program interface |
| **ARP** | address resolution protocol |
| **ASIC** | application-specific integrated circuit |
| **BGP** | border gateway protocol |
| **Broadcast** | Broadcast or flooding is a simple routing algorithm in which every incoming packet is sent through every outgoing link except the one it arrived on.  |
| **CAPEX** | capital expenditure |
| **CHAP** | challenge handshake redundancy protocol |
| **CLI** | command line interface |
| **CO** | central office |
| **Controller** | see *SDN Controller* |
| **CPU** | central processing unit |
| **Data link layer** | The second lowest layer of the seven-layer Open Systems Interconnection (OSI) model of computer networking. |
| **DDoS** | distributed denial of service |
| **DHCP** | dynamic host configuration protocol |
| **DPI** | deep packet inspection |
| **DNS** | domain name system |
| **East-West** |  |
| **FEC** | forward error correction |
| **Flood** | **Flooding** is a simple routing algorithm in which every incoming packet is sent through every outgoing link except the one it arrived on.  |
| **Frame** | a unit of data transferred over a L2 network |
| **FTP** | file transfer protocol |
| **FOSS** | free and open source software |
| **HTTP** | hypertext transfer protocol |
| **HTTPS** | hypertext transfer protocol secure |
| **iBGP** | interior border gateway protocol |
| **ICMP** | internet control message protocol |
| **IDS** | intrusion detection system |
| **Information model** | a set of entities, together with their attributes and the operations that can beperformed on the entities. An instance of an information model is visible at an interface. |
| **IPS** | intrusion prevention system |
| **IP** | internet protocol |
| **IP address** | the unique value assigned to each host on a computer network that is employing the Internet Protocol for addressing |
| **IPsec** | internet protocol security |
| **IPv4** | internet protocol version 4, using a 32-bit integer value for host addressing |
| **IPv6** | internet protocol version 6, using a 128-bit integer value for host addressing |
| **ISIS** | intermediate system to intermediate system protocol |
| **Layer** | a stratum in a framework that is used to describe recursion within the data plane. Adjacent layers have a client-server relationship. |
| **Layer 1 or Layer One or L1** | see Physical layer in the OSI model |
| **Layer 2 or Layer Two or L2** | see data link layer in the OSI model |
| **Layer 3 or Layer Three or L3** | see the network layer in the OSI model |
| **Level** | a stratum of hierarchical SDN or networking abstraction. |
| **LAN** | local area network |
| **LIFO** | last in/first out |
| **LLDP** | link layer discovery protocol |
| **MAC** | media access control |
| **MAN** | metropolitan area network |
| **MPLS** | multiprotocol label switching protocol  |
| **Network layer** | Provides the functions and processes that allow data to be transmitted from sender to receiver across multiple intermedia networks. |
| **NFV** | network function virtualization |
| **NOC** | network operations center |
| **NOS** | network operating system |
| **NV-GRE** | network virtualization using generic routing encapsulation |
| **OFA** | OpenFlow agent |
| **OFC** | OpenFlow controller |
| **OPEX** | operational expense |
| **OS** | operating system |
| **OSPF** | open shortest path first |
| **OVSDB** | Open vSwitch database management protocol |
| **Packet** | a unit of data transferred over an L3 network. |
| **Packet switch** | A packet switch is a node in a network which uses the packet switching paradigm for data communication. Packet switches can operate at a number of different levels in a protocol suite; although the exact technical details differ, fundamentally they all perform the same function: they store and forward packets. |
| **Physical layer** | lowest layer of the seven layer Open Systems Interconnection (OSI) model of computer networking |
| **PKI** | public key infrastructure |
| **Port** | A virtual data connection between computer programs connected through a computer network |
| **RDP** | remote desktop protocol |
| **Router** | A router is a networking device that forwards data packets between computer networks. A router is connected to two or more data lines from different networks (as opposed to a network switch, which connects data lines from one single network). When a data packet comes in on one of the lines, the router reads the address information in the packet to determine its ultimate destination. Then, using information in its routing table or routing policy, it directs the packet to the next network on its journey. |
| **RSVP** | resource reservation protocol |
| **SDN** | software defined networking |
| **SDN Architecture** | The SDN architecture is:* Directly programmable: Network control is directly programmable because it is decoupled from forwarding functions.
* Agile: Abstracting control from forwarding lets administrators dynamically adjust network-wide traffic flow to meet changing needs.
* Centrally managed: Network intelligence is (logically) centralized in software-based SDN controllers that maintain a global view of the network, which appears to applications and policy engines as a single, logical switch.
* Programmatically configured: SDN lets network managers configure, manage, secure, and optimize network resources very quickly via dynamic, automated SDN programs, which they can write themselves because the programs do not depend on proprietary software.
* Open standards-based and vendor-neutral: When implemented through open standards, SDN simplifies network design and operation because instructions are provided by SDN controllers instead of multiple, vendor-specific devices and protocols.
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| **SDN Controller** | A software entity that has exclusive control over an abstract set of data planeresources. An SDN controller may also offer an abstracted information model instance to at least one client. |
| **SLA** | service level agreement |
| **SNMP** | simple network management protocol |
| **Switch** | A network switch (also called switching hub, bridging hub, officially MAC bridge) is a computer networking device that connects devices together on a computer network, by using packet switching to receive, process and forward data to the destination device. A network switch forwards data only to one or multiple devices that need to receive it, rather than broadcasting the same data out of each of its ports. |
| **TCP** | transmission control protocol |
| **TLS** | transport-layer security |
| **UDP** | user datagram protocol |
| **Virtualization** | an abstraction whose selection criterion is dedication of resources to a particular client or application. When the context is general, for example when speaking of virtual network elements (VNEs), the term virtual may be used even when abstract might suffice. Virtual is also sometimes used colloquially to mean non-physical. |
| **VM** | virtual machine |
| **WAN** | wide area network |
| **WLAN** | wireless local area network |
| **XML** | extensible markup language |

**Recommended Equipment & Software Buildout**

Note: The ONF Certified SDN Engineer certification presupposes that the candidate have experience with the actual building and deployment of SDN networks, to that end, the candidate should familiarize him/herself with the following tools and build or otherwise have access to the following tools, preferably in a testing (non-operational) network. In this manner, the candidate can build, examine, test, and evaluate SDN tools, architectures, and networks thoroughly.

**Equipment**

* Patch Panels
* Punch downs blocks
* Layer 3 Switch
* Router
* Firewall
* Two basic PCs
* Access point
* Media converters
* Configuration terminal (with telnet and SSH)

Hardware

* NICs
* Network switches/hubs
* Power supplies
* GBICs
* SFPs

Spare parts

* Patch cables
* RJ-45 connectors, modular jacks

Tools

* Telco/network crimper
* Cable tester
* Punch down tool
* Cable striper
* Coaxial crimper
* Wire cutter
* Tone generator

Software

* Packet Sniffer
* Protocol Analyzer
* Mininet
* Flowsim

Terminal Emulation Software

* Linux/Windows OSs
* Software Firewall
* Software IDS / IPS
* Network mapper
* Virtual network environment

**References**

Links to relevant material to be added at final publication.